

# **NASA's Sun-Earth Connection Theory Program – Into 3rd Decade**

**From presentation at Fall 2002 AGU Meeting, San Francisco, CA  
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# OVERVIEW

NASA's Sun-Earth Connection Theory Program (SECTP) is now in its first year of a new triennial cycle of funded research, with all the research awards beginning in 2002. The SECTP, formerly the Space Physics Theory Program (SPTP), was initially established by the (former) Solar Terrestrial Division in 1980 to redress a weakness of support in the theory area. It has been a successful evolving scientific program for long-term funding of relatively large "critical mass groups" pursuing theory and modeling on a scale larger than that available within the limits of traditional NASA Supporting Research & Technology (SR&T) awards. The results of the program over the years has contributed to ever more cutting edge theoretical understanding of all parts of the Sun-Earth Connection chain, from the core of the sun out into the corona, through the solar wind into the Earth's magnetosphere and down to the ionosphere and lower atmosphere. In addition, it continues to support the development of more and more realistic computer models that have become the workhorses for analyzing satellite and ground-based measurements and in helping to plan and implement NASA spacecraft missions.

# HISTORY

- Established to redress perceived weakness in the theory area.
- (Former) Solar Terrestrial Division initiated it in 1980 as the Solar Terrestrial Theory Program (STTP) following a peer group study, *“The theoretical component of the space-plasma-physics effort needs to be strengthened by increased support and, most particularly, by encouraging theory to play a crucial role in the planned development of the field”* - NAS/NRC Space Science Board (1978).
- Until last year no comprehensive review of the Theory Program since its inception, but various study groups have always commented on it in supportive terms.
- 2001 R&A Senior Review gave a positive evaluation of SECTP accomplishments but queried its relationship to LWS theory/modeling and recommended more participation in mission development.
- Most recent cycle of 3-year SECTP research awards started this year.

# GOALS

- Purview encompasses solar physics, heliospheric physics, magnetospheric physics and ionospheric, thermospheric, and mesospheric physics.
- Longer term funding of relatively large “critical mass”, synergistically interacting groups of investigators to attack problems of fundamental importance within, or transcending, the boundaries of the different disciplines within the Sun-Earth Connection science theme.
- Pursue theory and modeling on a scale not readily supportable within confines of traditional NASA Science and Technology (SR&T) awards.
- Support NASA missions and E/PO programs.
- Encourage the exploration and development of new areas in the Sun-Earth Connection, especially interdisciplinary ones and perhaps objectives for future space missions.

# BUDGET HISTORY

<i><b>FY</b></i>	<i><b>FUNDING (in \$M)</b></i>	<i><b>NOTES</b></i>
80	2.25	.
*		*No Info Available 81-84
85	3.30	
*		*No info available 86-88
89	3.85	<i>Part of increase in late 80's due to formation of Space Physics Division in 1987 and transfer of cosmic ray and mesospheric physics into it.</i>
90	4.60	17 groups - <i>Budget high</i>
91	4.41	↓
92	4.30	
93	4.25	15 groups
94	4.12	↓
95	4.12	
96	4.13	14 groups
97	3.97	↓
98	3.97	
99	3.49	11 groups
00	3.23	↓ <i>All research awards cut by 5.8%</i>
01	3.47	
02	3.50	10 groups+2 phase downs
03	3.63(plan)	↓
04	3.76 (plan)	<i>New NRA to be released</i>

# ACCOMPLISHMENTS

- Outstanding example of benefits accrued from stable support.
  - Total of 36 groups have participated for an average tenure of ~ 9 Years.
  - SECTP scientists have been Pi's, Co-I's on spacecraft missions, organizers of topical conferences, participants in advisory and study groups at all levels.
  - Yielded models and research advances that would be nowhere near their current state of development without SECTP support. (e.g., TDIM, TIME-GCM, AIME, RCM, Sun/Magnetosphere MHD Codes...). These models are now integral parts of all mission planning and spacecraft/ground based instrument data analysis and Space Weather prediction activities.
  - Last 3 year cycle of support (1998-2001) yielded more than 440 publications. Thousands of publications over lifetime of program.

# Past Participants

- *Ashour-Abdalla, Maha*, UCLA  
**Magnetospheric, Magnetohydrodynamic and Kinetic Processes**
- *Bernstein, Ira B.*, Yale  
**Year-to-Centuries Timescales Solar Phenomena with Probable Terrestrial Consequences**
- *Chang, Tom*, MIT  
**Micro/Meso Scale Phenomena of Charged Particle Energization, Diffusion and Transport**
- *Chu Y.*, Aerospace Corp.  
**Electrodynamics of Magnetosphere-Ionosphere-Atmosphere Coupling: Auroral/ Global Connections**
- *Coroniti, F.*, UCLA.  
**The Coupled Magnetosphere/Auroral Arcs and Substorm Breakup**
- *Curtis, Steven A.*, GSFC  
**Multiscale Global Magnetosphere Simulations**
- *Dulk, G.*, U. Colorado  
**Turbulence and Wave Particle Interactions in Solar-Terrestrial Plasmas**
- *Ellison, Donald C.*, North.Carolina State  
**Particle Acceleration by Collisionless Shocks**
- *Hill, Thomas W.*, Rice U.  
**Three-Dimensional Structure of the Earth's Electromagnetic Field**
- *Goertz, C.*, U. Iowa  
**Physics of Magnetospheric Boundary Layers**
- *Goldstein, M.*, GSFC  
**The Role of Turbulence in Heliospheric Plasmas**
- *Gombosi, T.*, U., Michigan  
**Modeling of Non-Equilibrium Space Plasma Flows**
- *Hudson, Mary, K.*, U. C. B.  
**Theoretical Studies of Auroral Arc Formation**
- *Lee, Lou-Chuang*, U. Alaska, Fairbanks  
**Solar Wind-Magnetosphere Interaction at the Dayside and Nightside Magnetopause**

## Past Participants (continued)

- *Lyon, J. G.*, NRL  
**Three-Dimensional MHD Studies of Solar Wind- Magnetosphere-Ionosphere System.**
- *Lyons, L.*, Aerospace Corp.  
**Magnetospheric and Auroral Electrodynamics, Storms and Substorms**
- *Mariska, J. T.*, NRL  
**Modeling Dynamic Phenomena in the Solar Atmosphere**
- *Matthaeus, William*, U. Delaware  
**Turbulence and Transport Processes: Corona, Solar Wind, Cosmic Rays**
- *Omidi, Nojan.*, SciberNet, Inc.  
**Global Kinetic Simulations of the Interaction of Solar Wind and its Structures with the Magnetosphere**
- *Papadopoulos, Dennis*, U. Maryland  
**Studies of Discontinuities and Radiation Processes**
- *Rosner, Robert*, U. Chicago  
**Magnetic Field Dynamics in Solar Interior and Outer Solar Atmosphere**
- *Siscoe, George L.*, Boston University  
**Magnetopause Reconnection.**
- *Sudan, R.*, Cornell U.  
**Plasma Convection And Magnetic Field Reconnection in the Sun and in the Earth's Magnetosphere.**
- *Sturrock, P.*, Stanford U.  
**Research in Solar Plasma Theory**
- *Strauss, Henry R.*, Courant Inst., NYU  
**Solar Terrestrial Physics**
- *Van Hoven, Gerard*, U. California, Irving  
**Solar Plasma Theory**
- *Winske, Dan*, LANL  
**Energy Conversion Processes in Magnetospheric Boundary Layers**
- *Wu, C. S.*, U. Maryland  
**Plasma Processes in the Solar-Terrestrial Environment**



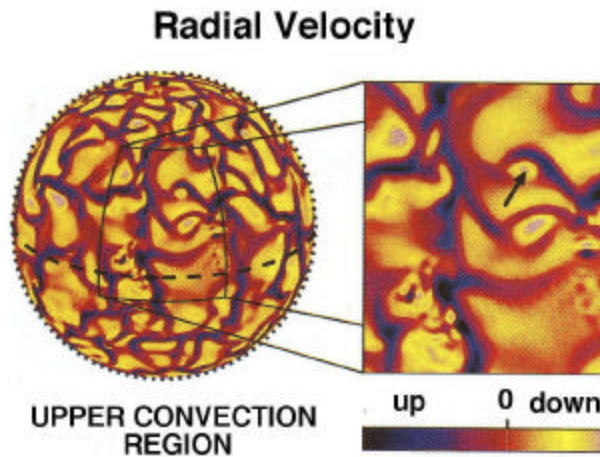
# CURRENT ACTIVITIES

- 10 Current investigations distributed uniformly from Solar Physics to Cosmic and Heliospheric Physics to Magnetospheric Physics and to Ionospheric, Thermospheric and Mesospheric physics
- All studies bridge coupling from one discipline into another
- Studies and models are directly involved with understanding data from, or in planning future activities of, the following missions: YOKOH, SOHO, TRACE, SOLAR-B, SOLAR PROBE, STEREO, WIND, ACE, ULYSSES, EQUATOR-S, POLAR, IMAGE, MMS, UARS, AE, DE, SME, Space Shuttle, DMSP, TIMED, GEC.

# CURRENT INVESTIGATIONS (2001NRA)

- *Antiochos, Spiro K.*, Naval Research Laboratory  
**Magnetohydrodynamic Processes in the Solar Atmosphere**
- *Birn, Joachim*, Los Alamos National Laboratory  
**Magnetospheric Dynamics: Kinetic and Fluid Aspects and their coupling**
- *Hollweg, Joseph V.*, U. New Hampshire  
**Theoretical Studies on the Solar Atmosphere and the Solar Wind**
- *Karimabadi, Homayoun*, U.C.S.D.  
**Collisionless Interaction of the Solar Wind with the Earth's Magnetosphere: the Global Nature and Consequences of Kinetic Processes**
- *Lotko, William*, Dartmouth College  
**Ultra-Low-Frequency Magnetospheric Physics: Scale-Interactive Processes involving Global Dynamics, Boundary and Internal Resonance Layers, Magnetosphere-Ionosphere Coupling, and Particle Energization**
- *Mikic, Zoran*, Science Applications International Corp., San Diego  
**The Structure and Dynamics of the Solar Corona and Inner Heliosphere**
- *Richmond, Arthur D.*, NCAR  
**Global Scale Interactions between the Mesosphere, Thermosphere, Ionosphere and Magnetosphere**
- *Schunk, Robert W.*, Utah State University  
**The Flow of Plasma in the Solar Terrestrial Environment**
- *Toomre, Juri*, U. Colorado  
**Aspects of the Global Solar Dynamo: Magnetohydrodynamic Models of Deep Convection and the Tachocline**
- *Wolf, Richard, A.*, Rice University  
**Magnetospheric Storm Dynamics**

# SUN-TO-EARTH CONNECTION OF CURRENT RESEARCH TASKS

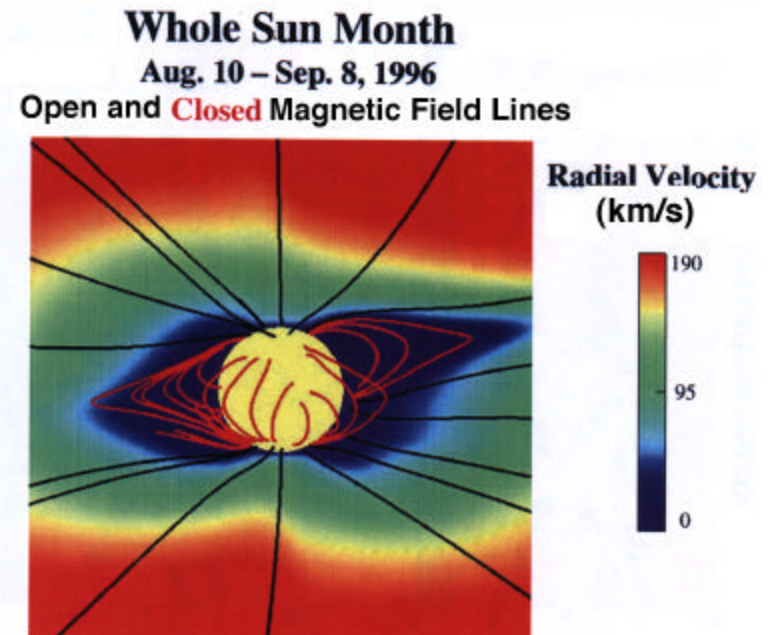
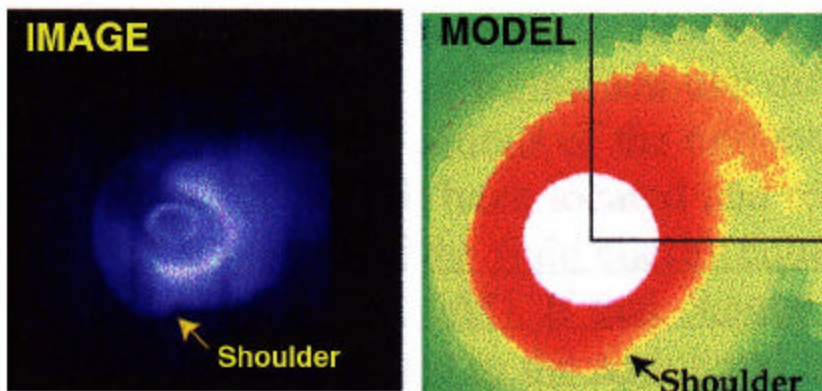


## SUN'S INTERIOR

- Dynamics of Sun's differential rotation and tachocline boundary layer, dynamic processes in Sun's deep interior and flux transport to surface.

## CORONA-SOLAR WIND

- Eruptive phenomena and magnetic connection in corona, coronal waves, coronal heating and solar wind acceleration, dynamics of solar magnetic flux tubes.
- Solar wind structures and processes (nonlinear Alfvén waves, corotating interaction regions).
- Turbulence processes in heliosphere. Cosmic ray transport.



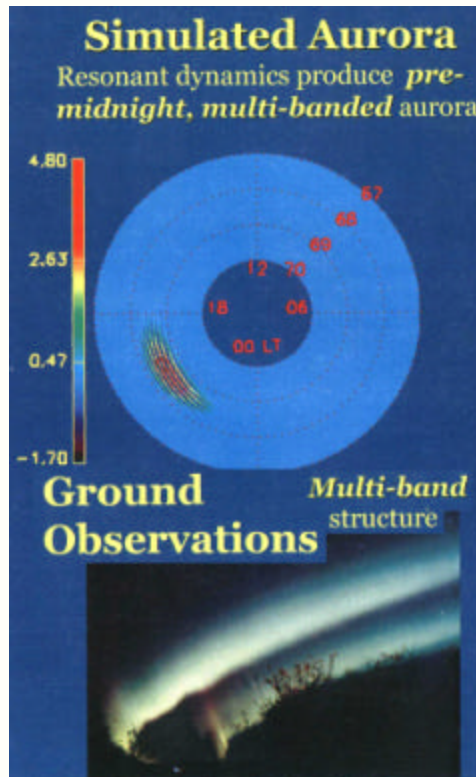
## SOLAR WIND-MAGNETOSPHERE

- Solar wind interaction, reconnection
- Thin Current Sheets, substorms, micro- and macrophysics and their coupling to dynamics
- Inner magnetosphere, including inner plasmasheet, plasmasphere, ring current and radiation belts.

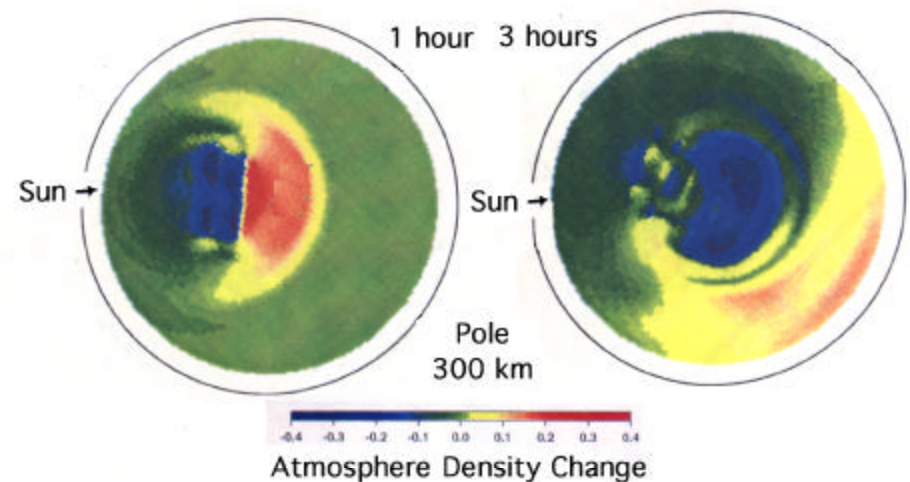
## ***SUN-TO-EARTH CONNECTION OF CURRENT RESEARCH TASKS (continued)***

### ***MAGNETOSPHERE-IONOSPHERE***

- *Magnetospheric Variability in ULF, magnetotail oscillations, magnetic pulsations, geomagnetic cavity and field line eigenmodes, auroral resonance/cavity dynamics.*
- *Response of coupled ionosphere-magnetosphere system to geomagnetic storms.*
- *Ionosphere-Polar Wind coupling and sources of magnetosphere plasma.*
- *Equatorial ionospheric disturbances due to high latitude magnetosphere disturbances.*
- *Dynamo feedbacks between magnetosphere and ionosphere.*



### ***Thermosphere Responds to Plasma Patch***



### ***IONOSPHERE-ATMOSPHERE***

- *Study of I-T system on different scales.*
- *Lower atmospheric sources of mesosphere/thermosphere disturbances,*
- *Upper atmosphere response to global change.*
- *Effects of tidal structures in middle atmosphere*
- *Source of low latitude electrodynamic variability, thermosphere response to high latitude inputs.*